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IMPROVED ROW-CROP SPRAYER AND DUSTER FOR POTATOES AND OTHER ROW CROPS[1/]

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A row-crop sprayer and duster has been specially designed and constructed for the application of agricultural chemicals to the foliage of row crops, with particular reference to the application of insecticides for the control of the green peach aphid (Myzus persicae (Sulz.)) on potatoes. This same principle was used in Maine in the early 1940's for applying pesticide sprays to potatoes and was reported by Slosser in 1945 3/. The sprayer-duster equipment reported here is an improved version of the original Slosser design. The present design is more flexible as it allows some horizontal as well as the vertical movement, also dust dispersal equipment has been added so that pesticides can be added in dry chemical form when desired.

DESIGN AND OPERATION OF SPRAYER-DUSTER

The spray nozzles and dust outlets which deliver the spray or dust are positioned at or near ground level by means of free-floating, trailing arms, the lower end of which are provided with shoes which slide along the surface of the ground. The spray emanates from two spray lines that branch in the shape of a T with nozzles mounted at the ends of the branch

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1/ Cooperative investigations of the Agricultural Engineering Research and Entomology Research Divisions, Agricultural Research Service, U.S.D.A., and the Oregon Agricultural Experiment Station.

2/ Young is an agricultural engineer and Chamberlin, Getzendaner, and Doenier are entomologists, all stationed at Forest Grove, Oreg.

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3/ J. W. Slosser. An Improved Sprayer Boom for Potatoes and Other Row Crops. Agr. Engin. 26(11): 453-455. 1945.

extensions. One line with its branch arms is mounted so as to treat the crop from the side and overhead and the other line is designed to treat the crop from near ground elevation and below the plant canopy. The dust tubes have right angle branches which are mounted near ground elevation and directed laterally and slightly upward so that the initial impact of the material is to the under surfaces of the leaves on the lower part of the plant canopy. The plant vines and leaves, particularly of a lush canopy, tend to confine and restrain the dissipation of the pesticide material. The trailing arm is mounted to trail in the furrow midway between rows. The T-extension arms extend outward toward the crop row to treat the sides of adjacent rows. The trailing booms are constructed to center themselves automatically between the rows and to follow this position regardless of regularity of the spacing or straightness of the planted rows. This design also incorporates a means of quickly adjusting the position of both the spray nozzles and the dust outlets. All the liquid lines are constructed of corrosion-resistant materials.

The unit consists of a tubular drawbar to which trailing booms are pivoted. These booms, mounted at right angles to the direction of travel, have two directions of free movement, namely, vertical and horizontal. The number of trailing booms employed with any piece of equipment is determined by the number of rows to be treated. If both sides of all rows are to be treated simultaneously, the trailing booms should be one more than the number of rows to be treated. The unit described herein was constructed with five trailing booms for treating both sides of four 30- to 36-inch rows so that it can be passed through farm gates without folding or dismantling.

This machine mounted on a drawbar of a row crop tractor is shown in figure 1. The crop duster and line shaft are mounted on a separate framework that is bolted to the tractor drawbar. The duster is powered from the tractor power take-off through a series of belt drives and an idler shaft. The trailing boom-drawbar is mounted to the rear of the platform with brackets to allow this drawbar to be rotated for lifting the booms. A short manifold is mounted to the center lifting-arm-bracket on the sprayer-duster drawbar from which hose leads are used to connect to the liquid lines of each trailing boom.

The spray equipment installation has the pump mounted on the left side of the tractor. Power is obtained from the tractor crankshaft at the front end of the motor through a clutch-controlled belt drive to the line shaft. The spray equipment may be operated at any time the tractor motor is running by engaging the clutch. It can be operated independently of or simultaneously with the dust equipment. This tractor-mounted installation is very compact; it allows maximum flexibility for turning at the ends of the rows or for maneuvering within the planted crop. The equipment is designed so that it may be mounted as a

separate unit on a trailer or another self-propelled vehicle such as a jeep or a light truck. When mounted as a separate unit, it is usually necessary to provide auxiliary gasoline-powered engines to drive the spray pump and duster unit.

Construction and Assembly. Pictorial views of the trailing boom units show the various components and their location on the trailing arm assemblies. The two views presented in figures 2 and 3 will assist in identifying the various component units shown in the detailed drawings in figures 4, 5, and 6. The detailed drawings show materials used, dimensions, and construction details.

A list of the kinds of material needed to construct a four-row machine and the approximate total cost is given on page 8. Because of their corrosion resistance, brass or copper pipes for the spray assembly lines are recommended over steel or iron tubing. Stainless steel would be suitable but may be higher in cost and more difficult to fabricate. If mild steel or iron is substituted in the construction, some provision should be made to protect the lines with rust inhibitors. Also, following periods of non-use, the lines should be flushed out before use to remove any loose scale or sediment that would otherwise clog the nozzles.

The drawings do not show the bracket for positioning the top spray boom with its extending branches. This bracket is composed of 2 two-piece clamps which grip the top and lower supply pipes and a 6-1/2 inch connecting strap. The clamps and connecting strap are constructed of 1/8" x 3/4" metal strap. The position of the top boom is adjusted by loosening the bolts in the clamping brackets and moving the brackets on the boom pipe.

The dust tubes are shown as being welded with one-directional position of the outlet. Some operators may prefer to use clamping brackets that will allow the tubes to be rotated within the mounting bracket. This modification would allow the operator to alter the outlet direction slightly for the various crops treated. The outside trailing booms have outlets on one side so that the equipment treats four rows simultaneously from two sides. The center three trailing units have double outlets for treating adjacent rows.

DUST AND GRANULAR EQUIPMENT

Dust and granular equipment consists primarily of a multiple outlet fan case and a hopper having a feed mechanism to regulate the delivery rate of dry materials. Various makes and designs are available through equipment dealers and may be obtained with or without a power supply. In general, a fan case with air outlets equally spaced around the circumference of the case will produce the most uniform distribution of air and

dry chemical. The number of outlets preferably should be equal to twice the number of rows treated so that each outlet will receive an equal proportion of the air and dry chemical. The delivery velocity of air at the outlets of the trailing boom described herein was approximately 40 mph or 3500 feet per minute.

SPRAY EQUIPMENT

The spray equipment consists of a 3/4-inch liquid pump, a pressure regulator and bypass valve, a pressure gage, a boom shut-off valve, a filter, a tank, connecting lines, and nozzles.

Pump. The pump may be either a piston, gear, centrifugal, or nylon roller type depending on the spray mixtures, the readily available sources of supply, and system of drives. The pump should be constructed of corrosion-resistant materials and have seals that are not affected by the chemicals to be used. If wettable powders containing abrasive materials are to be used, the pump should be selected on this basis. The pump should have a pressure range of 0 to 100 pounds per square inch (psi) and a capacity at least twice the rate to be applied in order to return part of the liquid back to the tank for agitation purposes. A simple formula for computing the capacity needed is given under calibration heading.

Filter. An adequate filter should be installed between the boom and the pump on the pressure side of the system to screen out any scale, large particles of pesticide material, and other foreign matter too large to pass through the nozzle orifices. The filter unit preferably should be designed to allow removal of the filter screen or cartridge for easy cleaning without disconnecting the liquid lines.

Bypass and Pressure Regulator. A diaphragm type of pressure relief valve is recommended for regulating the liquid pressure to the nozzles and protecting the system against excessive line pressures. This type of valve normally is sensitive to small pressure changes and can be adjusted readily for working pressures by means of a T-handle which increases or reduces the tension of the regulating spring. These valves can be obtained for more than one pressure range and can be altered by replacing the spring. For this sprayer, a spring having an adjustment range between 25 and 150 psi should be ample.

Tank. The pesticide supply tank should be of ample capacity to eliminate the necessity of frequent filling. Operators have found that tanks having 30 to 40 gallon capacity, or a standard-sized oil drum, provide ample storage for most purposes. Because of corrosion difficulties, some operators prefer either to use tanks constructed of fiberglass reinforced plastic or to line their metal tanks with a fiberglass reinforced

plastic similar to that found in boat kits. Tanks not lined with a protective coating should always be cleaned thoroughly after use and be protected with rust inhibitors. The supply tank should be provided with an outlet of a size equal to or slightly larger than the intake size of the pump. An additional outlet should be provided near the bottom of the tank for the return flow from the bypass valve to agitate the spray formulation. Pumps other than positive displacement types require that they be mounted so that their inlet is level with, or lower than the tank outlet or the pump will lose its prime between periods of operation.

Nozzles. A diaphragm type of check valve and nozzle is recommended. This type of check valve keeps the liquid lines filled so that there is no time lag in starting spraying at the beginning of the rows. Such valves also prevent leakage from the booms when the shut-off valve is closed. A pressure bleed from the line to the supply tank that opens when the shut-off valve is in the closed position and closes when the shut-off valve is opened keeps the operation of the spray application almost simultaneous with the operation of the shut-off valve.

Nozzles are manufactured with three principal types of spray patterns; namely, hollow cone, solid cone, and fan or flat spray. Each spray pattern type is further divided into angles of spray pattern produced which generally is designated by a prefix number. Ordinarily a spray angle of from 50 to 65 degrees is ample for most spray application with this sprayer. A 90 to 100 degree angle usually provides a much finer spray and also a broader zone of coverage which may be advantageous for the lower nozzles where the point of discharge may be unusually close to the treated leaf surfaces. In general, a higher degree of atomization is normally obtained with the cone-shaped patterns than with the fan- or flat-spray type. The nozzle capacity should be selected on the basis of the rate of discharge desired. This information can be obtained from nozzle manufacturers who supply their dealers with tables that give the discharge capacity and angle of spray pattern produced at given pressures.

Calibration. The nozzle capacity required may be determined by use of a formula derived from the rate of travel, swath covered, and rate applied in gallons per acre, thus:

> (Row spacing (feet) times number of rows treated times tractor speed (mph) times the gallons per acre to be applied divided by the constant 495 = gallons per minute required.)

This amount divided by the number of nozzles used will give the rate needed in gallons per minute per nozzle.

Example: Given: Row spacing 36 inches = 3 ft.
Number of rows treated 4.
Tractor speed 4.5 miles per hour.
Application rate - 16 gallons per acre.
Number of nozzles used (4 per row) = 16.

$$\frac{3 \times 4 \times 4.5 \times 16}{495} = \frac{864}{495} = 1.745 \text{ gal. per min.}$$

$$\frac{1.745}{16} = .109 \text{ gal. per minute per nozzle.}$$

It is usually advantageous to check a computed rate of application by an actual test run. The following formula may be used for checking the rate applied over a measured course of 40 rods:

$$\frac{66 \times \text{gal. used}}{\text{Row spacing (ft)} \times \text{No. rows}} = \text{gal. per acre applied}$$

Example: Given: Row spacing 36"
No. of rows 4.
Distance traveled 660 feet or 40 rods
Gallons used 2-1/2 gallons.

$$\frac{66 \times 2.5}{3 \times 4} = 13.75 \text{ gal. per acre.}$$

2.9 gallons should have been used to have had an application rate of approximately 16 gal. per acre.

RESULTS OF FIELD TESTS[4/]

The improved row-crop sprayer and duster received extensive field testing during 1955 and 1956 on seed potatoes in the Klamath Falls area of Oregon. The equipment proved mechanically reliable and extremely efficient both as a duster and sprayer.

These tests were conducted for the control of the green peach aphid which is important as a vector of leaf roll disease. A high degree of control is essential, therefore, in producing virus-free tubers for use as seed.

4/ Conducted in cooperation with Joe Schuh, consulting entomologist at Klamath Falls, Oreg.

Materials tested with this equipment included spray formulations of demeton as an early-season preinfestation systemic spray and both dust and spray formulations of Endrin and Diazinon. Excellent results were obtained with all three materials in all formulations tested.

Demeton spray at a gross rate of 16 gallons and a net rate of 8 ounces of demeton per acre, applied as soon as germination was nearly complete and well before the first influx of aphids into the field, gave substantial protection throughout the season. Control percentages at six weekly intervals from influx to harvest were 98, 94, 91, 89, 83, and 71 percent, respectively, or an average mean seasonal value of 88 percent relative to untreated checks. (NOTE: Although no further applications were made during the season, satisfactory control was maintained for several weeks.)

Both Endrin and Diazinon applied for the control of established infestations were extremely effective (99 to 100 percent at the end of the first week; 96 to 99.6 percent at the end of the second week; and 94 to 97 percent at the end of the third week) when applied with this equipment even after the vines were very large and luxuriant. Also, no significant mechanical damage to the vines was noted in making these applications. These tests showed that Endrin at 0.6 lbs. and Diazinon at 1.1 to 1.2 lbs. net per acre, applied either as a dust or a finely atomized spray, gave excellent control of established infestations of the green peach aphid on the under surfaces of the lower leaves of potatoes. Clouds of both spray and dust applied by this machine are retained by and circulate throughout the foliage for a considerable time even under windy conditions as a result of the barrier provided by the plant canopy or overlapping upper leaves. Effective insecticidal contact is thus insured.

Conventional ground sprayers and dusters were not available for comparison tests, but both Endrin and Diazinon applied at up to twice the rates noted gave no control whatever in the case of dusts and only partial control when applied as sprays by low flying aircraft--a method essentially comparable to the usual ground applications from a boom mounted above the vines only.

While field tests have not been conducted for insect pests of other crops, this equipment should be readily adaptable for insect pests occupying specialized microhabitats on almost any other low growing row crop.

MATERIAL NEEDED TO CONSTRUCT 4-ROW SPRAYER AND DUSTER BOOM

1/8" Black iron water pipe	- 2 feet
1/4" Black iron water pipe	- 3 feet
1/4" Brass water pipe	- 25 feet
3/4" Brass water pipe	- 4 feet
1/4" Brass T's	- 20 needed
1/4" Brass pipe plugs	- 4 needed
1/8" Brass pipe plugs	- 5 needed
1/8" Brass Street L's	- 16 needed
1/4" Brass couplings	- 3 needed
3/4" to 1/4" Reducing couplings (Brass)	- 2 needed
3/4" Couplings (Brass)	- 1 needed
1/4" Brass elbows-45 degree	- 2 needed
1-5/8" ID Solder joint brass elbows-90 degree	- 8 needed
1-5/8" ID Solder joint brass elbows-45 degree	- 8 needed
Iron flats	- 1-1/2" x 1/2" x 40" long
Iron flats	- 3/16" x 1" x 6 ft. long
Iron flats	- 1/8" x 2" x 10 ft. long
Iron round	- 1/4" dia.rod-5 ft. long
Iron round	- 3/8" dia.rod-20 ft. long
Angle iron	- 1" x 1" x 1/8"-8 ft. long
3/4" OD Shelby tubing - 11 gage	- 12"
3/4" OD Shelby tubing - 3/8" ID	- 6 ft.
3/4" OD Shelby tubing - 9/16" ID	- 12"
2" OD Shelby tubing - 22 gage	- 12" (dust hose size)
1-5/8" OD Welded tubing - 18 gage	- 12 ft.
1-1/8" OD Welded tubing - 16 gage	- 16 ft.
2-1/4" OD Welded tubing - 11 gage	- 12 ft.
Bolts 3/8" x 4"	- 15 needed
Bolts 1/4" x 3/4" SAE thread	- 35 needed
Bolts 1/4" x 4" SAE thread	- 4 needed
Lock washers or fiber lock nuts	- 40
Silver solder	- 2 troy oz.
Silver solder	- flux
1/16" mild steel welding rod	- 1 lb
3/32" mild steel welding rod	- 2 lb.
Coil springs - 3/4" OD x 6" long	- 10 needed
Paint	- 1 quart
Cotter pins - 3/32"	- 24 needed
Hose & fittings-1/4" ID(150 lb.psi) hose	- 13 ft.
Hose & fittings-3/16" ID(150 lb.psi) hose	- 6 feet
Hose ends (to fit 3/16" SAE flare fitting)	- 10
1/4" flare fitting 1/4" pipe	- 10
#4664 Diaphragm Teejet nozzle with flat spray orifice #650067 or equivalent	- 16

Approximate cost of materials is $225.00.

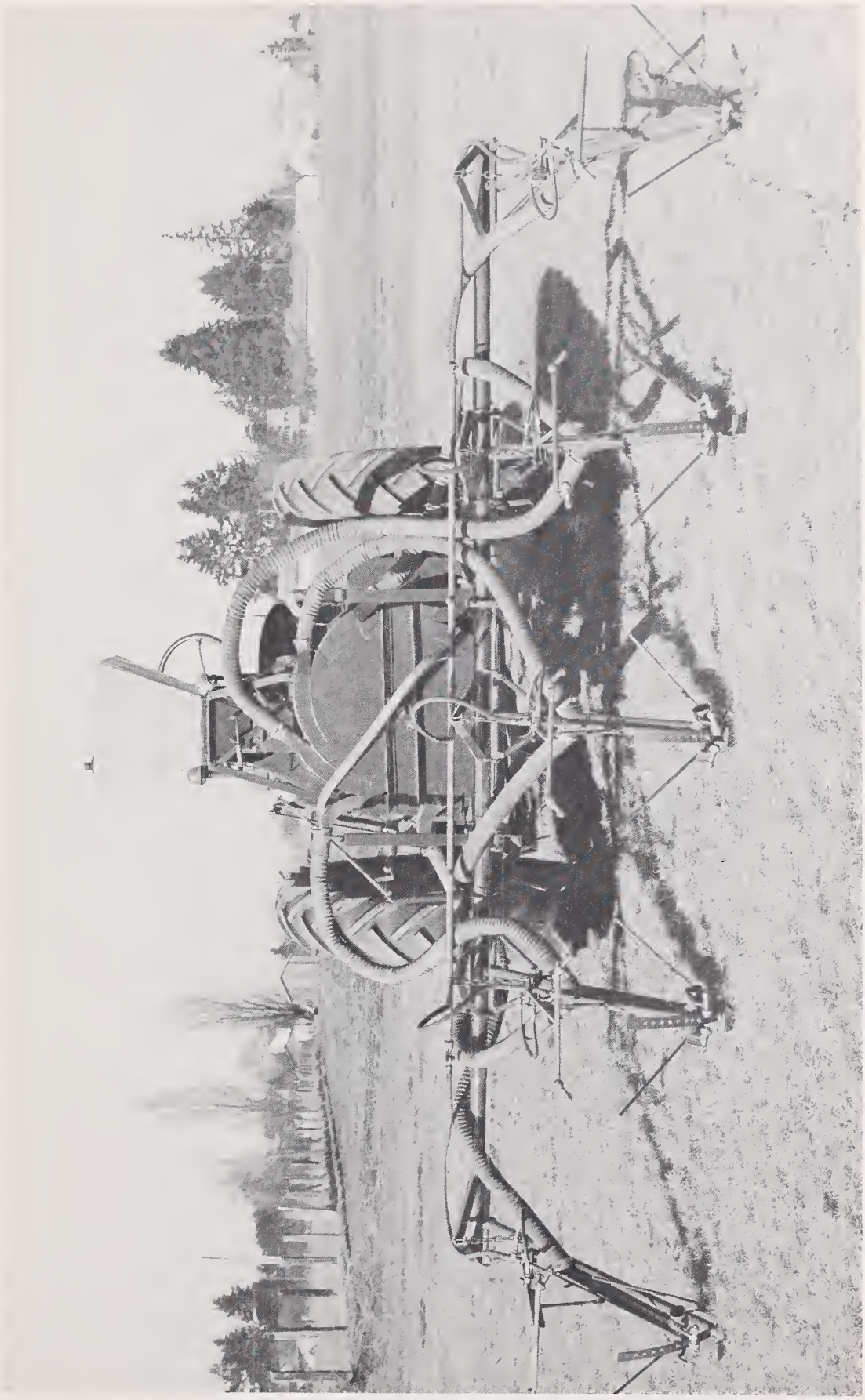

Figure 1. Rear view of tractor mounted row-crop sprayer and duster.

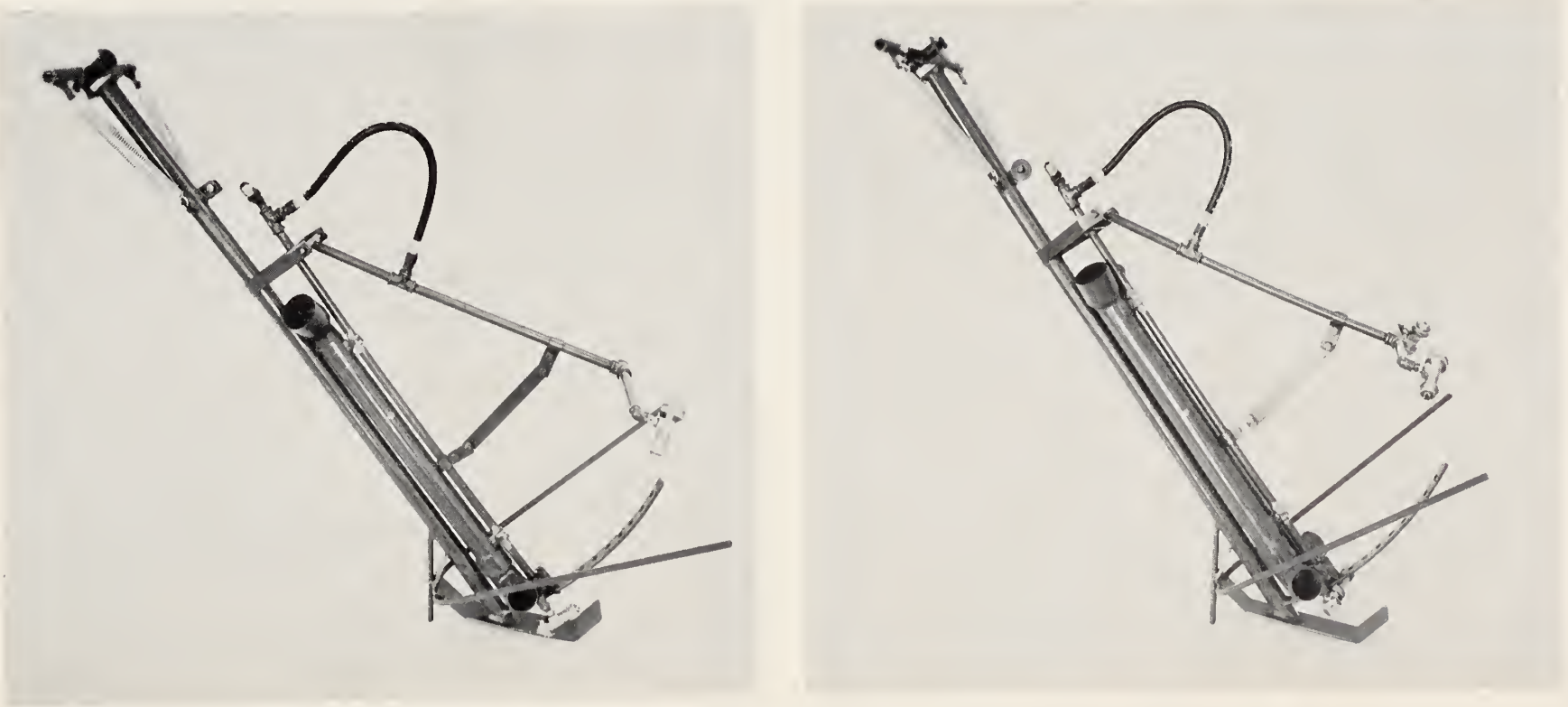

Figure 2. Side view of trailing boom showing construction of dust tubes and liquid lines.

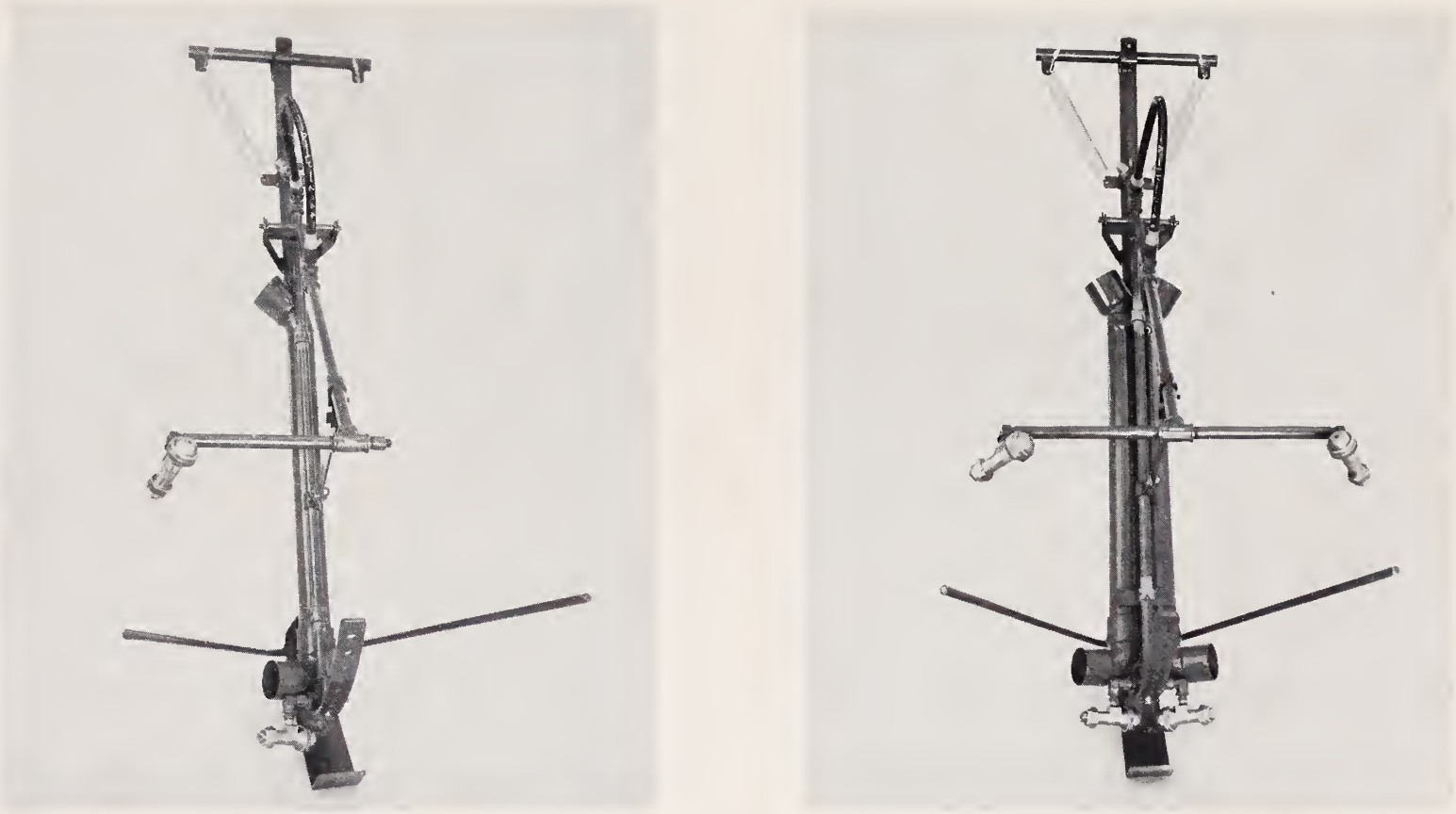

Figure 3. Rear view of trailing boom showing position of dust outlets and nozzles.

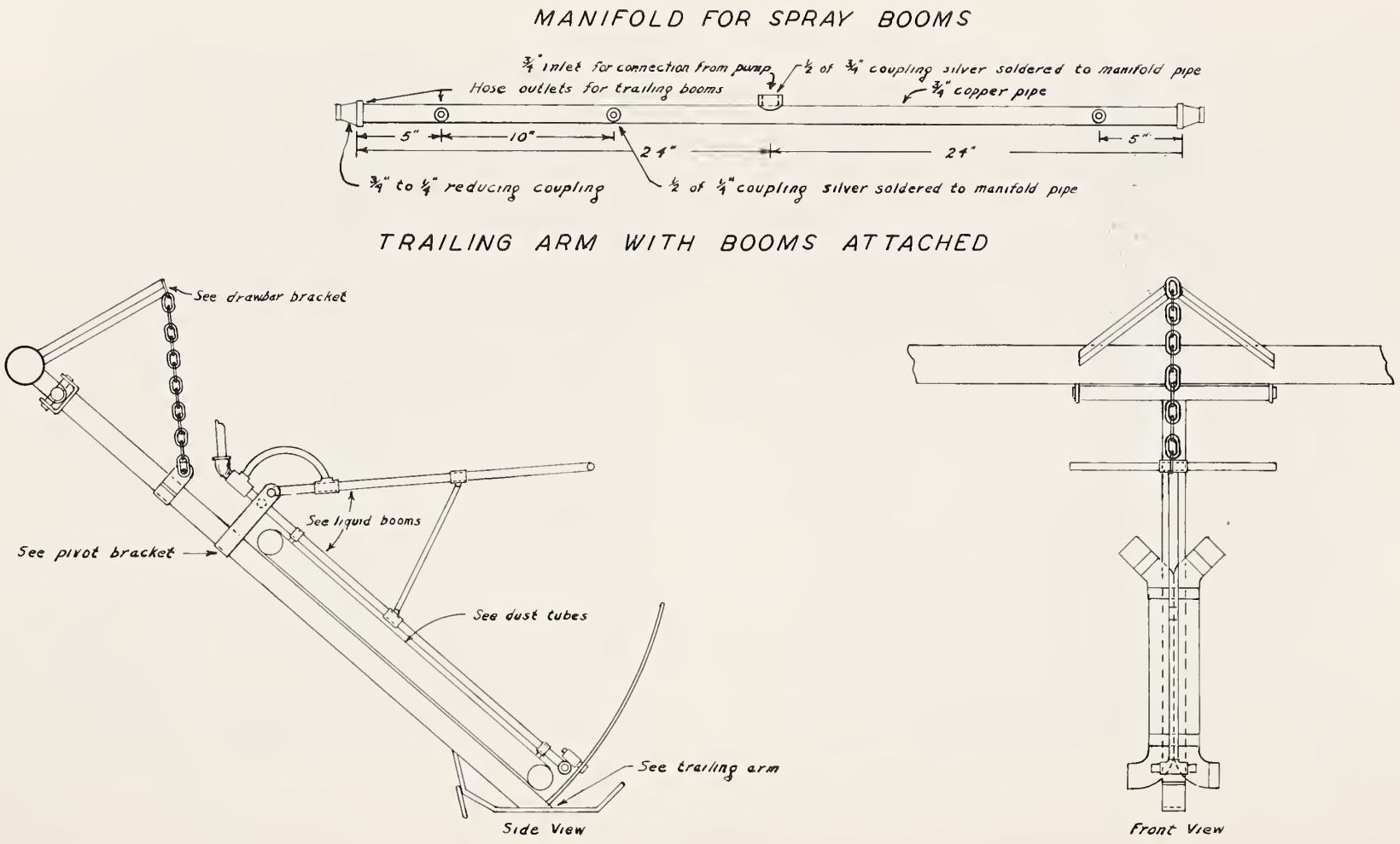

Figure 4. Detail drawing of manifold for sprays and two views of trailing boom attachment.

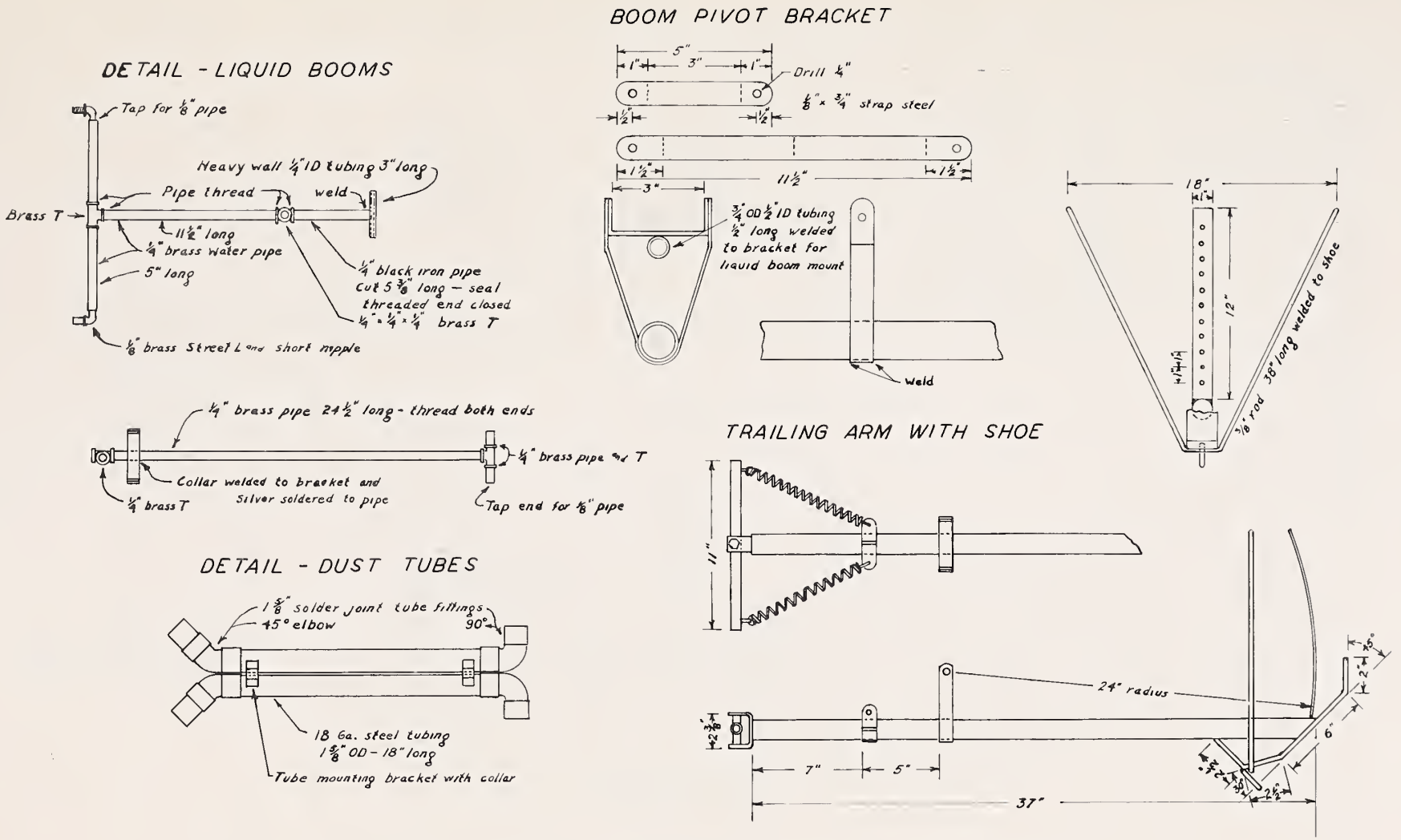

Figure 5. Detail drawing of components of trailing boom assembly.

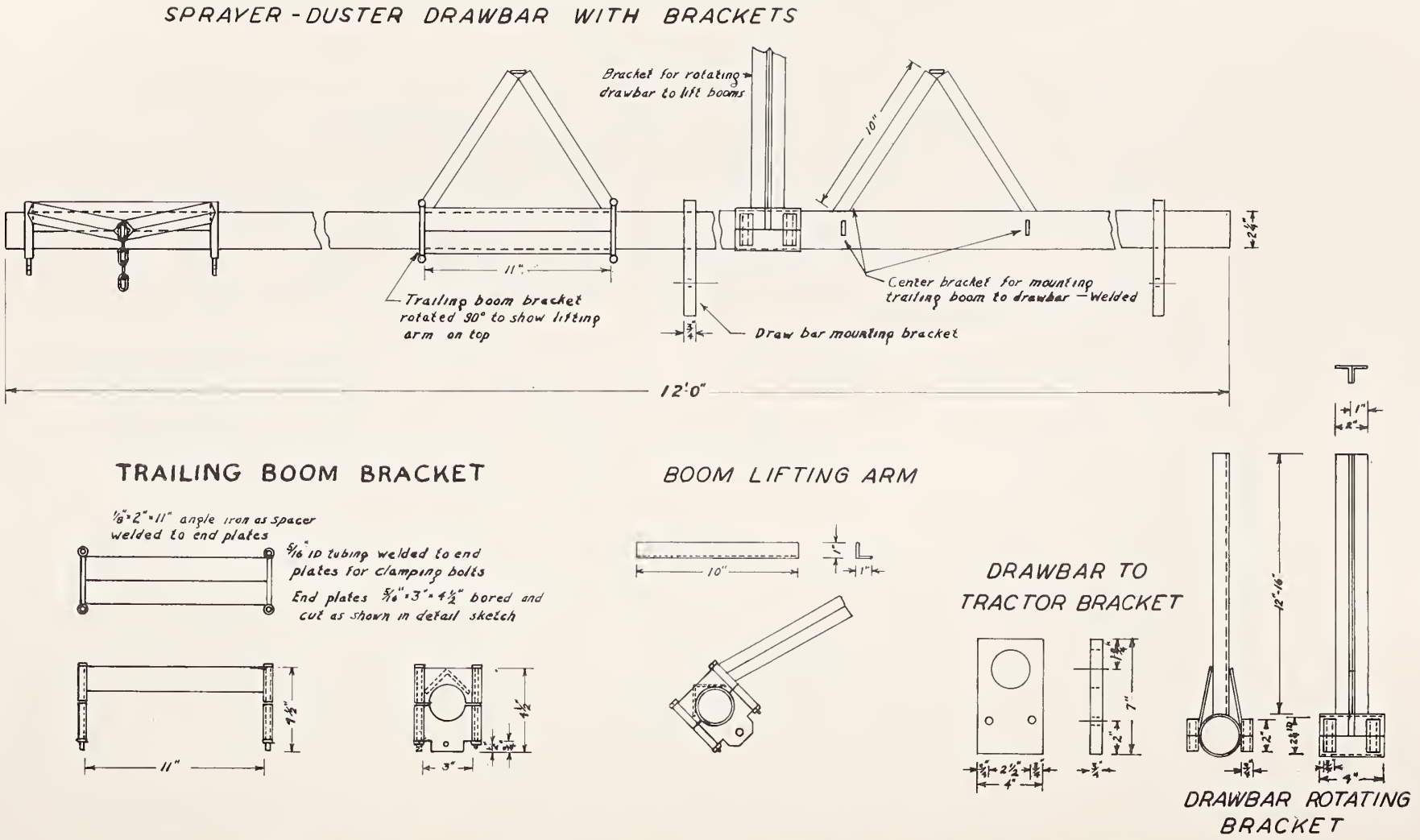

Figure 6. Detail drawing of trailing boom, drawbar, and bracket assemblies.